R E P O R T R E S U M E S

ED 003 606 56

GROUP VERSUS INDIVIDUAL PACING IN PROGRAMED INSTRUCTION.

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REPORT NUMBER NDEA-VIIA-847 PUB DATE 61
GRANT OEG-7-47-000-158
EDRS PRICE MF-$0.09 HC-$0.72 18P.

DESCRIPTORS- *PROGRAMED INSTRUCTION, *PACING, TIME FACTORS (LEARNING), *STUDENTS, HIGH SCHOOL STUDENTS, *HETEROGENEOUS GROUPING, *HOMOGENEOUS GROUPING, MONMOUTH, OREGON

A STUDY WAS CONDUCTED TO INVESTIGATE FEASIBLE CONDITIONS FOR ADAPTING SELF-INSTRUCTIONAL TECHNIQUES TO GROUP SETTINGS. THREE HYPOTHESES WERE TESTED--(1) THE TIME REQUIRED TO COMPLETE A PROGRAM BY A HETEROGENEOUS GROUP-PACED GROUP IS SIGNIFICANTLY GREATER THAN THAT OF A HETEROGENEOUS INDIVIDUALLY-PACED GROUP, (2) THE TIME REQUIRED TO COMPLETE A PROGRAM BY A HOMOGENEOUS GROUP-PACED GROUP DOES NOT DIFFER SIGNIFICANTLY FROM THAT REQUIRED BY A HOMOGENEOUS INDIVIDUALLY-PACED GROUP, (3) THE TIME REQUIRED TO COMPLETE A PROGRAM BY A HETEROGENEOUS GROUP-PACED GROUP IS SIGNIFICANTLY GREATER THAN THAT REQUIRED BY A HOMOGENEOUS GROUP-PACED GROUP. HIGH SCHOOL FRESHMEN PROVIDED THE SAMPLE. PRETESTING MADE UP THE HOMOGENEOUS AND HETEROGENEOUS GROUPS. TWO SECTIONS OF A LINEAR, SKINNERIAN-TYPE PROGRAM IN MODERN MATHEMATICS WERE USED FOR CONDUCTING THE EXPERIMENT. NONPARAMETRIC STATISTICAL PROCEDURES WERE USED FOR ANALYSIS OF DATA. THE "WILCOXON SIGNED-RANK TEST" WAS USED TO TEST HYPOTHESES ONE AND TWO. THE "WILCOXON COMPOSITE-RANK TEST" WAS USED TO TEST HYPOTHESIS THREE. ALL THREE HYPOTHESES WERE SUBSTANTIATED. (HB)

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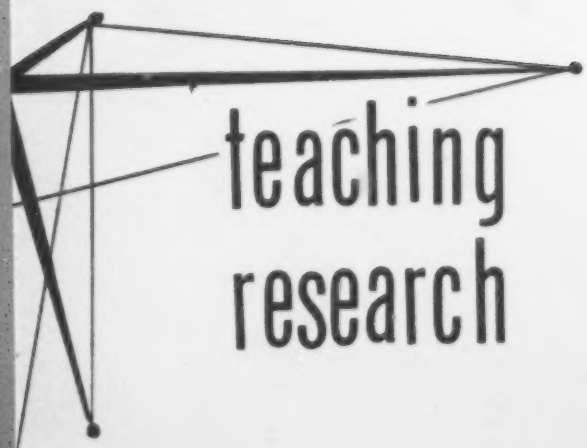

OREGON STATE SYSTEM OF HIGHER EDUCATION

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The Research Reported Herein was
Supported by a Grant from the
U. S. Department of Health, Education and Welfare

ED 003606

ACKNOWLEDGMENTS

For their contributions to this research effort I express gratitude to: Clifford Norris, Superintendent, School District 13CJ; Clarence Mellbye, Principal, Central High School; Donald Stensland, Mathematics Instructor, Central High School; Lewis Eigen and Jerome Kaplan, The Center for Programed Instruction, who together with Science Research Associates granted permission to use portions of the Modern Mathematics program.

Group vs. Individual Pacing in Programed Instruction

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Self-instructional programs (teaching machines) have demonstrated their efficiency. The literature is replete with evidence that learners using teaching machines perform as well as those using more traditional methods and often cover the material in less time (Fry, Bryan and Rigney, 1960; Galanter, 1961; Lumsdaine and Glaser, 1960; Stolurow, 1961). Typically, the use of the teaching machine has been limited to individual instruction, as well it may be. Attempts to visualize an entire school system in which the major instructional effort is of an individual nature have been limited although some effort along these lines has been made (Bushnell and Cogswell, 1961). The limited scope of such attempts may be the result of the difficult administrative and technological problems involved.

Problems of an administrative sort are apparent. Provided that students may proceed at their own rate in the use of self-instructional devices, after the first period of instruction it would be purely accidental for any two students to be working at the same place in a given program. It might be further contended that the longer they work in that program or in other programs in the same content area the wider the span would become. Empirical evidence is not available to support or reject such a hypothesis. Such differences in placement might or might not obtain in all content areas. Individual differences in specific abilities may or may not allow groups of students to remain somewhat close together in terms of their total progress. For example, the rates with which an individual student progresses through programs in language arts, social studies, mathematics, and science might differ from those of another student, but the two might complete all programs at the same time. This would make it feasible to organize the school on the basis of a single student characteristic, chronological age, for example. On the other hand, if some general ability determined the rate with which students progress through

all types of programs, wide discrepancies might soon result, and it would be difficult, if not impossible, to administer a graded school system.

If it were found that wide discrepancies in student placement did not result from completely individualizing instruction, then the currently used administrative organization would appear appropriate. Were such discrepancies evident, however, some new administrative schema would be necessary. Technologically, we are not ready for the latter possibility.

The demonstrated efficiency of programed materials has not been accidental. The procedures of programing are based in sound learning theory. It seems appropriate to assume that some of the principles that are used in programed instruction might well be used to improve our traditional instructional techniques. Under certain conditions self-instructional materials might be adaptable to group instruction in the traditional classroom. If the latter alternative proved feasible, the use of programed materials in group situations might prove to be an acceptable interim procedure prior to widescale use of self-instructional devices in the classroom.

Proponents of group instruction argue that use of the self-instructional devices precludes the operation of certain group behaviors which further enhance learning. Of primary importance among these group behaviors are those which are motivational in nature. Obviously, the use of self-instructional materials in a group limits the full contribution of some group dynamics, e.g., verbal interaction, cooperative problem solving, and constructive criticism; however, one, competition, may still operate. The motivational attributes of competition within the group has been demonstrated (Sims, 1928).

This study was designed to investigate some of the conditions under which the adaptation of self-instructional techniques to a group setting are most feasible. Previous studies (Briggs, Plashinski and Jones, 1955; Feldhusen and Birt, 1962) have revealed no significant differences in achievement when individuals are self-

paced and automatically-paced. In both studies, however, achievement was determined by scores on a post-test. Such studies suggest that group-pacing techniques will not seriously impede the learning process, but they do not reveal whether or not group-pacing seriously affects the rate of learning. It was to the latter problem that this study was directed.

Hypotheses

Theoretically, if a group of learners were composed in such a way that all learners had the same ability patterns, motivational levels, and previous experiences, it would be expected that they would reach the same learning objectives in the same time. If such a group were then exposed to a set of programed materials in such a manner that progression through the materials were to be made as a group, it could be expected that the group members would complete the program as quickly as a group as they would if working individually. Further, if given a set to work as quickly as possible, the competition among the members might even improve the learning rate. Practically speaking, such ideal grouping procedures are impossible; however, some degree of homogeneity may be obtained. Logically, the greater the degree of homogeneity exhibited by a group, the greater will be the similarity between the group-paced and individually-paced learning rates.

Four groups of 11 Ss each comprised the sample (N=44). Two groups were homogeneously determined on the basis of IQ and predicted algebra ability. One of the homogeneous groups was group-paced (HomGP) and the other was individually-paced (HomIP). The two heterogeneous groups were also different in that one was group-paced (HetGP) and the other, individually-paced (HetIP).

The following hypotheses were tested:

1. The time required to complete the program by the HetGP group is significantly greater ($p < .05$) than that of the HetIP group.

2. The time required to complete the program by the HomGP group does not differ significantly ($p < .05$) from that required by the HomIP group.

3. The time required to complete the program by the HetGP group is significantly greater than that required by the HomGP group.

Procedure

The sample was chosen from high school freshmen students enrolled in a beginning algebra course during the 1961-62 school year. Each subject completed a pretest designed to measure basic algebraic concepts. Only those Ss who demonstrated that they could solve quadratic equations by factoring and by completing the square and who, at the same time, were not familiar with the quadratic formula, were selected for the study.

Two sections of a linear Skinnerian-type program were used.[1] The "Completing the Square" section and "Quadratic Formula" section contained 47 and 88 frames respectively. Each frame was typed on a separate sheet with a primer typewriter and then microfilmed. Eleven copies were duplicated for filmstrip use and one for slide projection. The Ss were asked to construct their answers on notebook paper. Eleven 150 watt filmstrip projectors were used to project the materials. The criterion performance for the experiment was perfect completion of a post-test which required each S to recall the quadratic formula, substitute two given equations into the formula and to make minor simplifications. Four parallel forms of the post-test were prepared in order to eliminate practice-effect errors from those who were required to review the program and repeat the test (see test forms in Appendix C).

Individually-paced Ss worked in carrels constructed of four-foot-square sheets of pegboard hinged together. A filmstrip projector was placed on the desk top of each subject's chair. The program frames were projected about three feet to a screen attached to the carrel. The Ss each controlled their own projectors.

The group-pacing equipment consisted of an automatic slide projector with the remote control modified in such a way that it would advance the projector only after

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[1] Pre-publication material from The Center for Programed Instruction, now published in revised form in Modern Mathematics: A Programed Textbook, Science Research Associates, Chicago, Illinois, 1962, ch. 68-69.

all Ss had responded. Depressing the button engaged a relay which relieved S of the necessity of holding the button down. When the projector advanced, all relays were simultaneously released (see schematic diagram in Appendix B). A portable 3' x 4' screen was used to display the projected program.

The experiment was conducted in a large, dual purpose (cafeteria-auditorium) room in a nearby high school. The two installations (group-paced and carrels) were situated about 50 feet apart. The experimental groups did not interfere with one another.

Selection of experimental subjects. The subjects who participated in the experiment were matched on the basis of their performances on the Primary Mental Abilities (PMA) test and the Orleans Algebra Prognosis (OAP) test scores. Both tests had been administered during the previous year. The subjects were assigned to the treatment groups in such a way that each subject in one of the two group-paced groups was matched with a subject in the corresponding individually-paced group. Within practical limitation, those subjects assigned to the homogeneous groups were within the second and third quarters of the distributed abilities of the total sample. Likewise, those subjects assigned to the heterogeneous groups were within the first and fourth quarters of the distribution. The pairing was done in such a way as to minimize the discrepancies between paired subjects and at the same time retain nearly equal mean ability levels in the four groups. Five Ss were shifted after the original assignments were made because their class schedule was in conflict.

By the following procedures an approximate duplication of the experimental groupings could be accomplished: (1) transform each individual's PMA score to a percentile rank and combine it with his OAP score; (2) construct an array of the resulting composit scores; (3) assign those individuals whose scores fall in the first and fourth quarters of the array to the heterogeneous groups and assign those whose scores fall in the second and third quarters of the array to the homogeneous groups; (4) arrange matched pairs within the heterogeneous and homogeneous groups; (5) randomly assign one member of each pair to the individually-paced and one to the group-paced treatments; (6) make adjustments to retain comparability of PMA group means.

Statistical analysis. The use of the more powerful parametric statistical treatments was precluded by the nature of the assignment of the Ss to the experimental groups. Consequently, nonparametric statistical procedures were used in this study. The Wilcoxon Signed-Rank Test (Siegel, 1956, pp. 75-83) was used to test Hypotheses 1 and 2. The Wilcoxon Composite-Rank Test (Guilford, 1956, p. 251) was used to test Hypothesis 3.

Data Collection. During the time that the Ss were working on the program, their time and place of meeting was rearranged in accordance with the requirements of the experiment. The HomGP Ss met together during the first period and the HetGP Ss met together during the second. The individually-paced Ss met during their regularly scheduled class period. In order to have a uniform number in each experimental session, vacant stations were filled arbitrarily with other students.

The Ss were instructed to keep an accurate account of the actual time (in minutes) spent working on the filmed material and to turn this in, together with their item responses, at the end of each work session. The experimental program was completed by the first S (HetIP) in three work sessions and by all Ss in eight. The Hom GP group finished during the sixth session; the HetGP during the seventh.

Review was necessary for those Ss who failed the post-test. For the individually-paced Ss, the procedure was simply to repeat that part of the program with which they were having difficulty, log the extra time which was later added to the total learning time, and take a different form of the post-test. For the group-paced Ss, those passing the post-test were dismissed and those requiring review continued to use the group-paced device, beginning at the point where all understood the program. The group-paced Ss then proceeded rapidly as a group through the remainder of the program. The spaces vacated by those who had passed were deactivated by taping down the buttons.

In all, 13 of the 44 Ss required at least one review session and two required a second. Review sessions varied from about 10 to 30 minutes (see data in Appendix D).

Results

The data from this study are summarized in Table I. The reported values are the median number of minutes required by the experimental groups to complete the program. The following results obtained:

Hypothesis 1. The time required by the HetGP group is significantly greater than that of the HetIP group. The results of the Wilcoxon Test substantiated the hypothesis.

Hypothesis 2. The time required to complete the program by the HomGP group does not differ significantly from that required by the HomIP group. The results of the Wilcoxon Test substantiated the hypothesis.

Hypothesis 3. The time required to complete the program by the HetGP group is significantly greater than that required by the HomGP group. The results of the binomial test substantiated the hypothesis.

Table I

Median Time in Minutes Required for Each Experimental Group to Complete the Program

Pacing Technique	Homo-geneous	Hetero-geneous	Difference
Group	255	325	70[a]
Individual	221	240	19
Difference	34	85[a]	

[a] Statistically significant ($p < .01$)

Discussion

Verification of the experimental hypotheses indicate that a number of possible conclusions are appropriate. Considering the data in terms of the degrees of homogeneity exhibited by the groups, the experiment provided evidence that there is some merit in grouping students homogeneously according to ability if programed materials are to be presented in group-paced manner in a classroom.

Consider the entries in Table I. Apparently, only when there is a wide discrepancy in abilities within a group is there any liklihood that learning rate will be retarded by forcing the learners to progress at the rate of the group. The extremely slow learning rate of the HetGP group cannot be explained in terms of the lower abilities of some of the members of that group. The ability levels of the slower students in each experimental group were remarkably similar. The degree of homogeneity in each of the experimental groups was primarily a function of the abilities of the more able members of each group. Thus, it appears that some condition or combination of conditions other than ability operated in this experiment to bring about the obtained results. One explanation is that when a student is working in a group of students with like abilities, he recognizes the similarities and as a result feels more able to play a competitive role; however, when a student of lower ability is placed in a group which has other students who are much more capable, he tends to withdraw from any competition and becomes more cautious. The dynamics of group behavior under these circumstances merits further study.

Another factor, cost, which has not been considered previously, deserves mention. The HomGP Ss used a single program and a single teaching device to serve the entire group, whereas the individually-paced Ss each required a program and a device. Monetarily, therefore, much can be said for the use of group-paced equipment. In this limited experiment, the individual student stations cost $9.27 per S and a like amount would have been necessary for each additional S whereas the group equipment averaged $4.68 per S and only $2.50 (approximately) would have been necessary for each additional S. The savings would soon become substantial in larger installa-

tions.[1]

As a pilot effort, this study suggests the "efficiency" potential that group-pacing techniques with programed materials have in the context of a graded school system, but many questions still remain unanswered. Research is needed to test whether goal-attainment time does, in fact, decrease as a function of the degree of group homogeneity. The hypotheses of this study need to be tested at other age levels, with different disciplines using various group-pacing procedures. The present study strongly favors such further investigation.

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[1] The figures are based on rental fees of projectors, film preparation costs and equipment necessary to expand the group device.

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Appendix A

Pre-Test (Screening Test) - Sample

1. Find the values for x by completing each of the following problems.

   a. Factoring ☐ I don't know how.

   $3x^2 - x = 24$

   $3x^2 - x - 24 = 0$

   $(3x + \ ) (x \ \ )$

   b. Completing the square ☐ I don't know how.

   $4x\ (x - 3) = 21$

   $4x^2 - 12x = 21$

   $4x^2 - 12x + 9 = 21 +$

   c. Formula ☐ I don't know how.

   $3x^2 - 7x = 9$

   $3x^2 - 7x - 9 = 0$

   $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

   $x =$

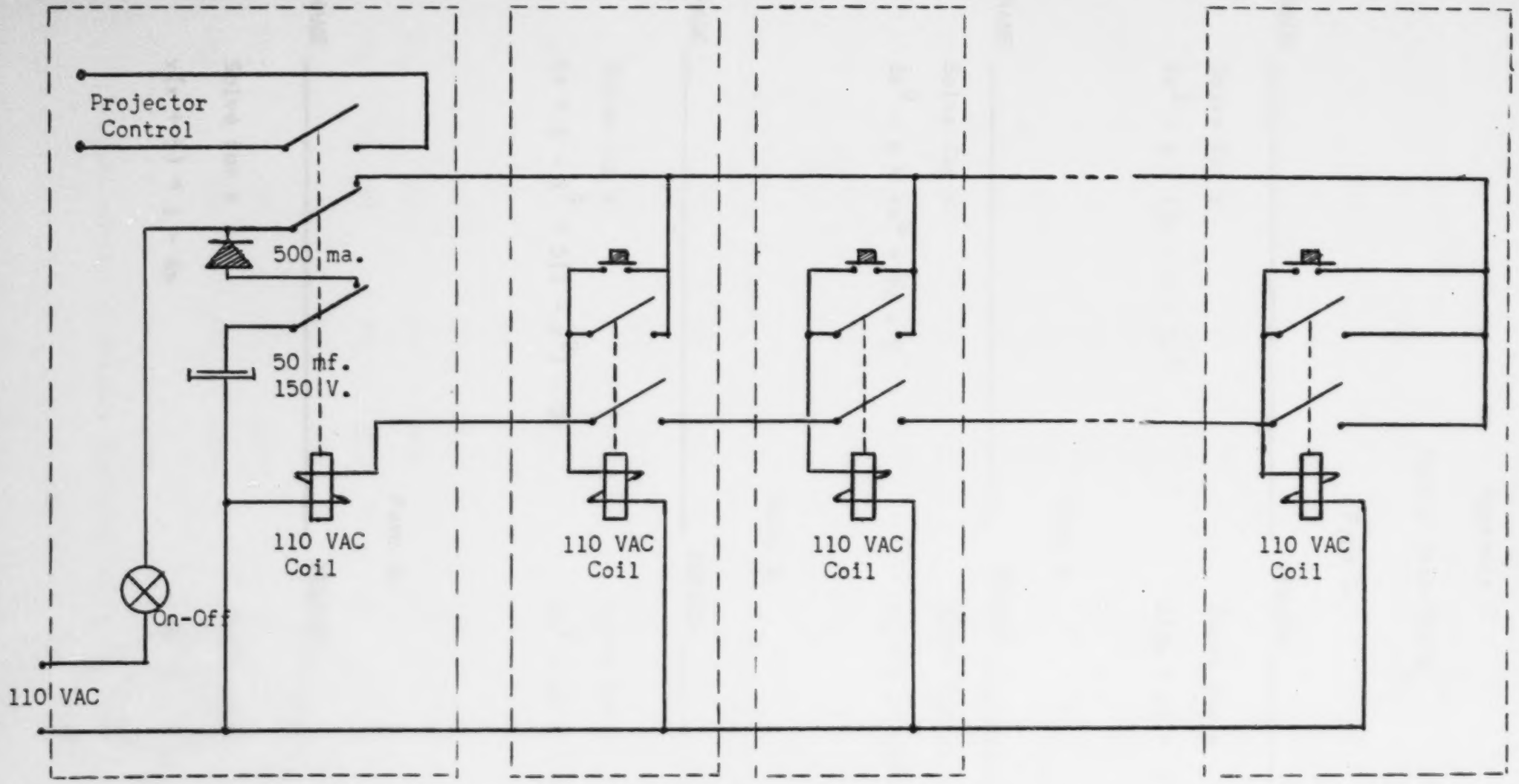
2. The following problem can be solved by three different methods. Show the complete solution using each method with which you are familiar.

   $x^2 + 8x = 20$

   a. Factoring ☐ I don't know how.

   b. Completing the square. ☐ I don't know how.

   c. Quadratic Formula ☐ I don't know how.



MULTIPLEX REMOTE PROJECTOR ADVANCE	
Project: Group-paced Self-instruction	
NDEA VII #7-47-0000-158.0	December 20, 1962
Charles Frye	TEACHING RESEARCH, OSSHE

Appendix C

Sample Post-Tests

Form 1.

NAME _____ PERIOD _____ TIMES TESTED _____

Solve for x

$3x^2 - 4 = 12x - 8 + 2x^2$

Solve for m

$m(dm + e) = -f$

Form 2.

NAME _____ PERIOD _____ TIMES TESTED _____

Solve for x

$6x^2 - 6 = 4x^2 + 7x - 2$

Solve for w

$hw + k = -gw^2$

Form 3.

NAME _____ PERIOD _____ TIMES TESTED _____

Solve for x

$6x + 6 - x^2 = 5(1 - x^2) - 2x$

Solve for b

$kb^2 + mb = - n$

Form 4.

NAME _____ PERIOD _____ TIMES TESTED _____

Solve for x

$x(x + 5) = 1 - 6x$

Solve for p

$yp^2 + s = -ep$

Appendix D

Homogeneous Groups				Heterogeneous Groups			
Student no.	PMA IQ	OAP	TIme	Student no.	PMA IQ	OAP	Time
Group-paced (HomGP)				Group-paced (HetGP)			
1_a	90	61	256	23_l	91	55	325
2_b	89	67	255	24_m	93	40	325
3_c	90	71	240	25_n	132	55	325
4_d	108	85	240	26_o	104	57	325
5_e	104	55	262	27_p	85	67	338
6_f	93	86	268	28_q	87	65	325
7_g	99	57	319	29_r	125	61	325
8_h	95	67	268	30_s	116	63	325
9_i	95	72	240	31_t	123	93	325
10_j	113	81	240	32_u	126	92	325
11_k	102	95	240	33_v	137	97	325
Individually-paced (HomIP)				Individually-paced (HetIP)			
12_a	102	55	221	34_l	99	38	176
13_b	91	67	170	35_m	94	45	240
14_c	89	74	259	36_n	113	55	241
15_d	106	88	234	37_o	97	59	201
16_e	94	57	146	38_p	78	69	184
17_f	101	82	164	39_q	80	59	281
18_g	102	57	323	40_r	115	61	400
19_h	99	63	331	41_s	105	63	244
20_i	102	79	222	42_t	119	92	100
21_j	102	82	127	43_u	122	95	343
22_k	100	98	189	44_v	126	94	159

Similar subscript letters indicate the matched pairs.